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A versatile instrument for the measurement in r units of radiation doses

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With 5 figures in the text

Summary

The need is stressed of extensive investigations of the doses received in occupational work with ionizing radiations, by patients undergoing medical X-ray examinations, and from the natural radiation. A simple instrument, based on the condenser chamber principle, for the measurement of X-rays and γ-radiation in the range from the natural level of γ-radiation up to 150 r has been designed for such investigations. A similar instrument is used for large stationary ion chambers, where the voltage is read by means of an attached condenser which can be sent by mail. The technical arrangements are described.

Introduction

During recent years, increased interest has been focussed on estimation of the doses of ionizing radiations received by human subjects. This is partly because the genetic problems of radiation effects at the entry into the atomic age have reached a stage at which efforts must be made to ascertain the significance of increased irradiation for the development of mankind. Partly, however, it is also due to the greater use of X-ray examinations in medicine, which has actualized the question of the risks of dangerous exposure of single patients and of whole populations. Most investigations of the radiation doses from natural as well as from artificial sources are made by calculations based on the radiation fields, and on information about the time spent in different parts of the field.

In Sweden, for instance, about two million people undergo medical X-ray examinations every year. The average number of films exposed per person is 4.4, and in approximately 40% of the cases fluoroscopy is used as well. In 30–50% of the examinations, the gonads may on some occasions be exposed to primary radiation. Taking the whole population as approximately 7 million, the average dose to the gonads due to medical X-ray examinations amounts to 0.05–0.25 r per year. The contribution of odontological and mass-miniature examinations is so small that it can be disregarded, and the same applies to X-ray therapy, which produces a maximum irradiation of the gonads of the population of less than 0.01 r per year, if those patients are excluded who are irrelevant from the genetic point of view.

The occupational exposure can at present, when estimating the whole population dose, be disregarded in comparison with the exposure of the patients.

The doses from natural radiations in Sweden are of the magnitude of 0.05–0.5 r per year, the average gonad doses for the population probably being about 0.1 r

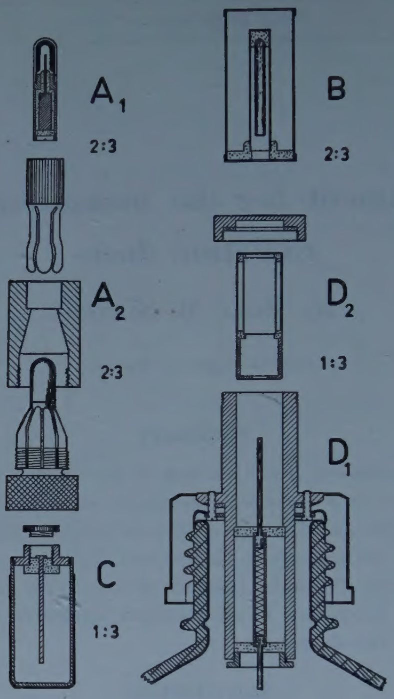

Fig. 1.

A_1	Condenser chamber, for maximum 30 and 150 r or 10 and 50 r.
A_2	Reduction tool for unscrewing chamber top from condenser for the voltage measurement.
B	Double condenser chamber, for maximum 0.25 and 2.5 r or 0.05 and 0.5 r.
C	Condenser chamber, for maximum 0.01 r or 0.002 r.
D_1–D_2	Movable condenser for voltage readings when using large chambers of type D_1.

per year. Consequently, the dose attributable to medical X-ray examinations is of the same order of magnitude as the average dose from natural radiations, probably about 3 r for a period of 30 years.

The figures given here are taken from recent estimates made at the Institute of Radiophysics [1, 2]. Estimates of this kind may, however, be misleading. Both the natural radiation and the radiation in medical X-ray examinations must be subject to direct measurements on a much larger scale than hitherto. The radiation fields are in both cases, especially the latter, so inhomogeneous that great errors are likely to occur unless data taken from direct measurements are collected. Direct observations on patients are also of importance, to state which X-ray examinations are followed by the highest gonad doses and must therefore possibly be avoided or undergo technical improvement.

At the Institute of Radiophysics, attempts have therefore been made to develop simple methods for radiation measurements, allowing a very great number of determinations to be made simultaneously. For this purpose, the condenser chamber method seems to be the most suitable.

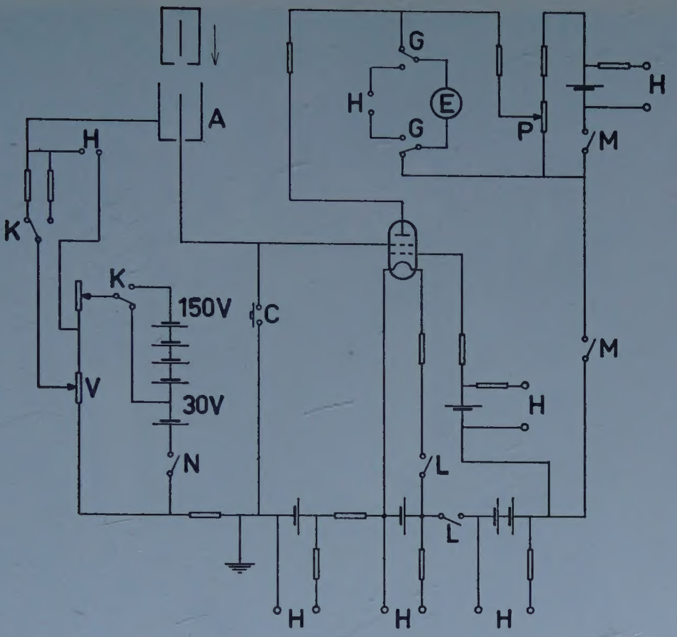

Fig. 2.

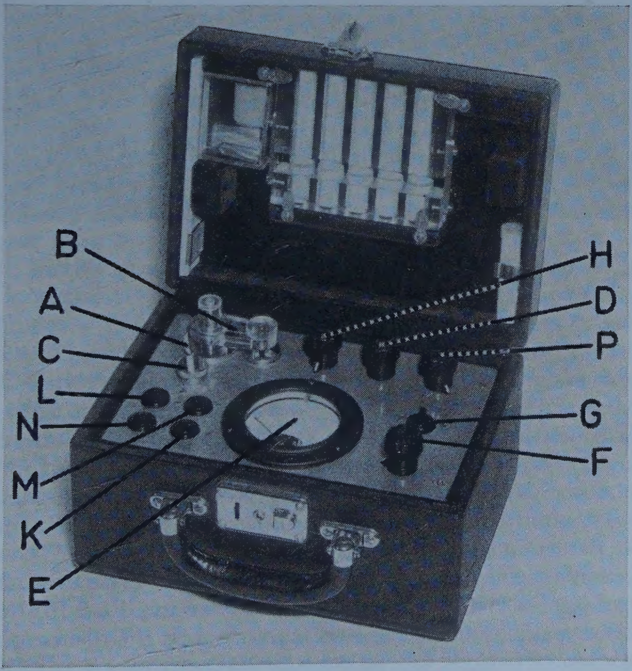

Fig. 3.

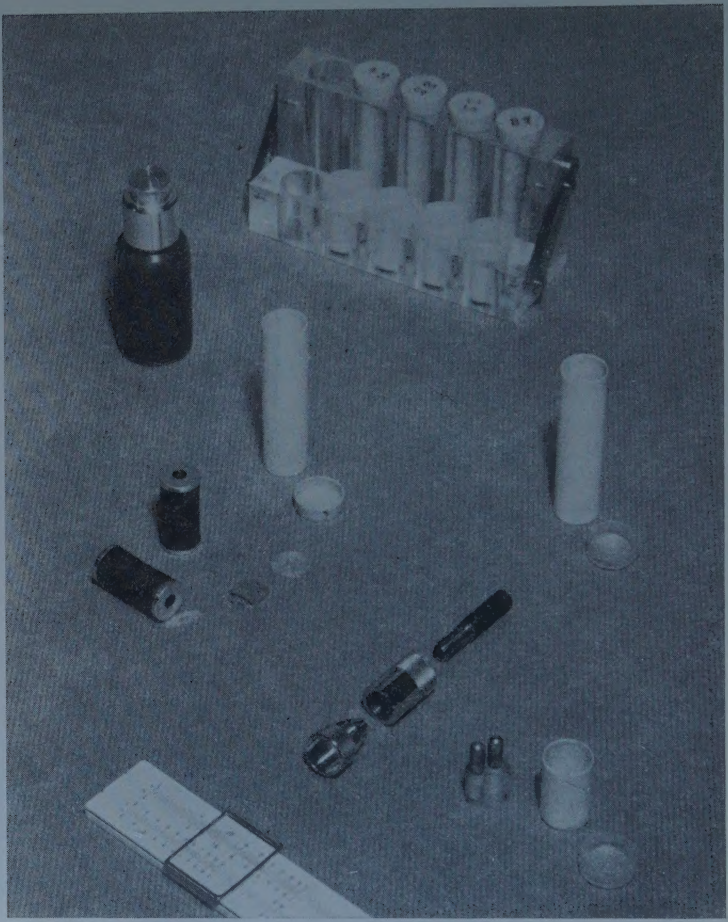

Fig. 4.

Method and instrument

The method of using an ion chamber separated from the voltage-reading instrument seems to have been first used for radium measurements in 1925 by Halledauer [3]. In 1926 [4], the author completed the method for higher radiation doses by connecting the ion chamber to a condenser of suitable capacity, and in 1931–32 [5, 6] the condenser-chamber method was given its final form by arranging the inner electrode so that very small chambers of suitable capacity could be made for most of the varying dose determinations necessary in radiology. In 1934 [7], small condenser chambers were designed for use in roentgen therapy, for doses up to 300 r and, later, up to 600 r. For large ion chambers, the method was modified [6] by using a small movable condenser, which is charged and connected to the discharged ion chamber and, after the exposure period, moved over to the reading instrument for measurement of the potential drop.

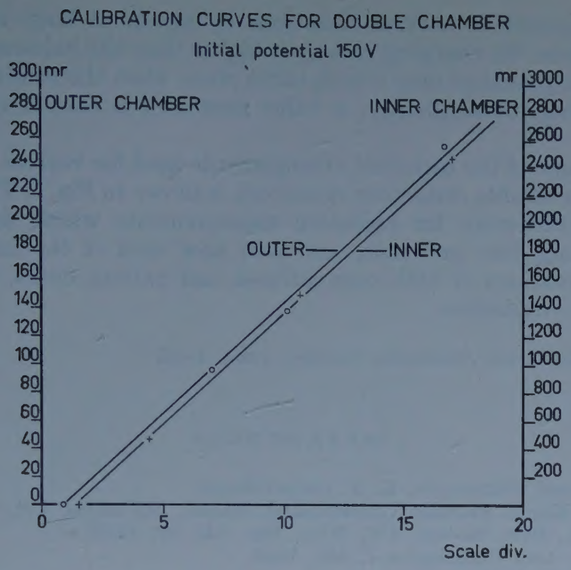

Fig. 5.

The increased need of a portable reading instrument and sets of chambers for the determination of doses of widely differing magnitude has led to the design of an instrument which can be used for γ- and X-rays from the level of natural radiation up to 150 r. It covers the range necessary for personnel monitoring in natural radiation milieu as well as in occupational work with ionizing radiations, and for observations of the dose to patients undergoing X-ray examinations.

The construction of the ion chambers, all of which are of airwall type, and the measurement condensers will be seen from Fig. 1, and the principle of the method for charging and determining the voltage from the wiring diagram in Fig. 2.

The readings are taken in the following way (see Figs. 2 and 3).

The condenser chamber is placed in an insulated container, *A*, and the flap, *B*, which connects the outer wall of the chamber to the balancing voltage, *V*, is shut. After having loosened the bottom, *C*, whereby the measuring system is unearthed, the chamber-holder is pressed down to bring the inner electrode in contact with the grid of an electrometer valve. The plate current (after being initially balanced by adjusting *P* so that the pointer of the μA-meter, *E*, is in the middle of the scale) now falls to zero or below. The deflection is brought to its original position by turning *F*. The system is then earthed by *C*, and the loss of charge is read on the instrument by switching *G* to its lower position, The dose in r units is obtained from the calibration curve for the ion chamber in question. After turning *F* back to zero, and switching *C* to its initial position, the chamber is removed and automatically charged.

The batteries are checked by turning *H* and the charging potential which can, by means of switch *K*, be alternatively fixed either at 30 or 150 volts. The charging potential can be adjusted by *D* so that when measuring the completely discharged chamber, the pointer of the μ A-meter reaches the end of the scale. The switches *L*, *M* and *N* are for filament current, grid voltage and balance current.

In the measurement of natural radiations by means of large ion chambers and movable condensers, the charging voltage is higher than the balance voltage, in order to account for the potential drop which takes place when the condenser is connected to the ion chamber. Consequently, a value near zero is read if no irradiation has taken place.

Fig. 4 shows some of the technical arrangements used for various purposes. A calibration graph for double condenser chambers is shown in Fig. 5. The instrument has proved to be satisfactory for radiation measurements which do not require an accuracy exceeding five per cent, and it is now used at the Institute of Radiophysics for observations of both occupational and patient doses, and for measurements of natural γ-radiation.

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